

A STOCHASTIC MODEL FOR BASE-OF-SALT MAPPING USING GRAVITY DATA

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RESEARCH OBJECTIVES

Mapping base-of-salt using gravity and gravity gradient data is subject to a large degree of uncertainty, because of measurement errors and ambiguity in those data. Deterministic methods are limited for characterizing this uncertainty, since the optimal estimates of base-of-salt rely on starting models, and sensitivity-analysis methods often underestimate the actual uncertainty in the estimation. Our goal in this study is to develop a stochastic model for mapping base-of-salt using gravity and gravity-gradient data. The model should provide not only the estimates of base-of-salt at each location, but also uncertainty information at the location, such as mean, variance, ranges, and possible multiple modes.

APPROACH

In this study, we assume that the seafloor and top-of-salt of a continuous salt body are known through seismic surveys. We consider the thickness of the salt body at each location in the area as a random variable and strive to estimate the probability distribution function (instead of a single value) of the thickness, using gravity and gravity-gradient data. First, we define a joint posterior probability distribution function for all the unknown thicknesses, using a Bayesian framework. Second, we develop a Markov chain Monte Carlo (MCMC) method to obtain many samples of each unknown variable. Finally, we estimate the mean, variance, density function, and predictive intervals of each unknown variable. We also compare the results obtained using stochastic models with those obtained using deterministic methods.

ACCOMPLISHMENTS

We tested our stochastic model using a simple synthetic data set, based on a seismic model of a Gulf of

Mexico site (Gemini) with one salt body, and a field data set collected from a North Sea site. We also explored the efficiencies of a variety of sampling methods, which included methods using gradient information, methods updating by columns, and methods updating by blocks. An image based on the Gemini data set is shown in Figure 1. Salt thickness uncertainty information at four locations is shown in

Figure 2, where locations were chosen at which the estimated thickness of salt is distributed bi-modally, with intermediate thickness less likely, given the measured gravity and gravity gradient data.

SIGNIFICANCE OF FINDINGS

Our stochastic model for mapping base-of-salt provides an effective approach for characterizing uncertainty in the estimation of base-of-salt, since it gives us not only the estimates of base-of-salt but also the possible modes, ranges, and distributions at the location. The stochastic model, if used together with a deterministic model, can significantly reduce the number of forward calculations needed for the MCMC sampling method. For example, we can start from the optimal solutions obtained from deterministic models and draw many samples from the initial values.

RELATED PUBLICATION

Chen, J., M. Hoversten, and T. Smith, Stochastic inversion of gravity data for mapping the base-of-salt. Geophysics (in preparation), 2005.

ACKNOWLEDGMENTS

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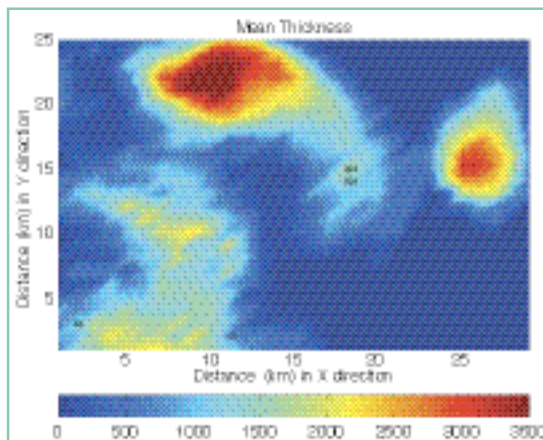


Figure 1. The estimated thickness of the salt body based on data collected from the Gemini data set. The numbers in the image show several locations where the thickness may have bi-modes.

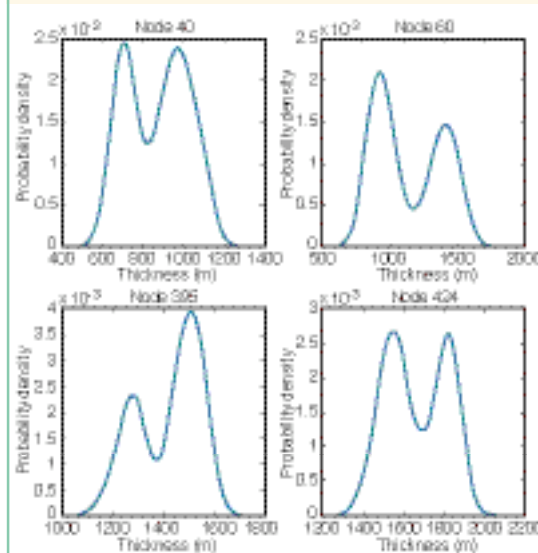


Figure 2. Probability densities for the salt-body thicknesses at the four locations, where the thickness may have bi-modes

